The Design, Manufacture, and Testing of a Container Module to Satisfy the IAEA Regulations for the Safe Transport of Radioactive Material, 1985 Edition (as Amended 1990), for the Transport of an Advanced Gas Cooler Reactor (AGR) Gas Circulator

K.C. Urch
Nuclear Electric plc

INTRODUCTION

Heysham I and Hartlepool are sister Advanced Gas-Cooled Reactor (AGR) nuclear power plants operated by Nuclear Electric plc. They share a common design of gas circulator; a total of eight circulators being installed in each reactor to circulate the primary coolant, CO_2, through the reactor core and boilers.

A total of four spare gas circulators were provided per station, which served to safeguard generation in the event of maintenance being required on an in-circuit unit. As an insurance measure against there being no fully overhauled gas circulator available, Nuclear Electric identified the requirements for a container module to transport a spare circulator between the stations should the need arise.

In such circumstances, it would be necessary to transport a gas circulator safely and with the minimum of radiological impact while complying with the relevant transport standards and regulations. To this end, a Gas Circulator Transportation Module was designed, manufactured and tested, and a safety case prepared to demonstrate compliance with the IAEA Regulations for the Safe Transport or Radioactive Material, 1985 Edition (As Amended 1990).

DESCRIPTION OF A GAS CIRCULATOR

The Heysham I and Hartlepool gas circulators (Figure 1) were manufactured by James Howden & Co Ltd, of Glasgow and are of the single state, centrifugal, vertically mounted type. They are driven by an enclosed 11kV motor at 3000 rev/min producing a CO_2 mass flow rate of nominally 475 kg/s. The circulators are essentially cylindrical, 6 metres in length, 2 metres in diameter and each weigh approximately 38 tonnes.

SPECIFICATION FOR THE TRANSPORTATION MODULE

The module in which a gas circulator was to be transported had to satisfy a number of differing criteria in order to be certified, as being suitable for use, by the Health and Safety Department of Nuclear Electric. The primary regulations are those as laid out in IAEA Safety Series No.6, and it was on this basis that the safety case was written. The safety case quantified the radiological hazards associated with the transport of a gas circulator and specified parameters for the design, operating and maintenance procedures in order to demonstrate regulatory compliance.

RADIOLOGICAL ASSESSMENT

The radiological hazards were addressed by consideration of a gas circulators operating environment. During operation, a circulator becomes contaminated due to exposure to the primary CO_2 coolant. The majority of this contamination is attributed to Sulphur-35 but there are also small amounts of Carbon-14 and metal activation products, alpha contamination being negligible.

Gas circulator activity levels were measured using a BP4 probe. These showed that α contamination of the gas circulator was negligible and that the majority of contamination levels were within the Surface Contaminated Object, Group II (SCO-II) classification band. The only exceptions were the levels of non-fixed contamination on some areas and as such some decontamination of local "hot spots" was necessary in order to achieve SCO-II classification. It was calculated that a probe reading of 200 cps (counts per second) would correspond to a surface contamination level of 400 Bq/cm^2, the limit for classification as SCO-II. In order to ensure compliance with the Regulations by some margin a limit of 150 cps was set. It was also determined from the surface dose rate measurements that dose rates for the circulator and the package were within regulatory limits.

A thin layer of oil forms on the gas circulator surface and it was possible that this oil could be contaminated with tritium. Since tritium contamination cannot be detected using a BP4 probe, calculations were carried out based on previous measurements of contaminated oil activity. These calculations showed that a 2mm thick layer of oil would be required over all of the gas circulator before SCO-II contamination limits were exceeded - an unlikely occurrence!

A circulator classified as SCO-II is suitable for transportation within an Industrial Package Type 2 (IP-2), the integrity of the package being demonstrated by compliance with the ISO Standards and test requirements for freight containers (Paragraph 523) and the corresponding paragraphs within the IAEA Transport Regulations. In order to further demonstrate that the transportation module designed to ISO Standards was fit for purpose, in both design and construction, independent design approval was obtained from Lloyds Register who also monitored the construction of the module and witnessed its type testing.

DESIGN OF THE TRANSPORTATION MODULE

The design of the module (Figure 2) was prepared on behalf of Nuclear Electric, based upon the ISO standards for freight containers and approved by Lloyds Register in accordance with their Container Certification Scheme. The principal features of the design were as follows:

- Manufactured from 5mm carbon steel plate with rolled hollow section (RHS) corner posts and vertical members. Base and roof perimeter frame from rolled steel universal column with rolled steel channel cross members and bracing.
- Fully seal welded in accordance with the requirements of ASME IX and AWS D1.1
- All node welds and lifting points subjected to a 100% magnetic particle inspection. Other welds subjected to a 20% random magnetic particle inspection.
- Carbon steel durbar pattern plate floor.
- The gas circulator supported in three locations within a cradle arrangement, the floor being strengthened locally to accommodate the load of 38 tonnes.
- Removable roof section, incorporating a special single seal gasket arrangement, secured to the main body of the module with internally fitted, lockable toggle clamps.
- Personnel door permitting access to the toggle clamps and the gas circulator within the module during loading and unloading.
- Module shot blasted and painted both inside and out. A three-coat paint system applied with a smooth acrylic urethane finish for ease of decontamination.
- Dimensions: 9.1m long x 3m wide x 2.7m high.
- Tare weight 14 tonnes; rated gross weight 52 tonnes.

It was decided that the module did not need to be suitable for lifting while loaded with a gas circulator. This requirement would have added considerably to the strength of the module and hence the cost. Instead the module will always be loaded onto its transporter prior to the gas circulator being loaded. This provision was written into the Operating Instructions for the module.

MANUFACTURE OF THE TRANSPORTATION MODULE

The module was manufactured to strict and comprehensive standards as part of an approved Quality Assurance System (BS5750) by Longwall MSC at their Nottingham works. Throughout all stages of manufacture, Lloyds Register monitored the quality systems, materials handling procedures, welder certification, materials certification, and working practices to ensure compliance with Paragraph 209 of the IAEA Transport Regulations.

TESTING

In order to comply with the requirements of the Certifying Authority, and to ensure that the constraints of the safety case were met, it was necessary to subject the completed module to a series of load and leakage tests. These tests were in accordance with the requirements of the International Standard ISO 1496 and as defined by Lloyds Register. The roof strength and leakage tests were conducted at the Longwall MSC site, with the remainder of the tests being carried out at the ISO Container Testing Centre located at Marthill Engineering on Merseyside.

Calibrated 1 tonne and 2 tonne concrete and steel blocks were used to apply load to the floor of the module. These were lowered through the roof opening onto skids which distributed the load between the three support cradle positions thereby representing the actual loading arrangement.

Those tests conducted are summarised below:

- Roof Strength Test
- Pressure and Leak Test (test pressure 70mbar)
- Lifting from the Top Corner Castings (internal load applied 14te)
- Base Frame Deflection (internal load applied 40te)
- Weathertightness Test

These tests, all of which were completed successfully, demonstrated the suitability of the transportation module for its intended duty. In accordance with approved procedures, a Certificate of Regulatory Compliance was issued by Nuclear Electric's Health and Safety Department.

USE AND TRANSPORT OF THE MODULE

The unladen module was first loaded onto a suitably rated trailer unit and lashed down securely with chains. In order to load the gas circulator, the trailer was reversed into the Station's Gas Circulator Maintenance Facility, where the pre-wrapped circulator was manoeuvred by crane from the maintenance area into position and lowered into the module. Once in place, it was securely fastened to the cradles and at its designated tie-down positions.

Thus secured and with the roof hatch locked in its transport position, the module was transported by road in accordance with the appropriate Road Transport Regulations and the County Police specified routing.

Operating and Maintenance Instructions defining the operational procedures and maintenance requirements were produced in support of the continued use of the module.

SUMMARY

The design, manufacture, testing, approval, and use of the Gas Circulator Transportation Module represents a significant achievement in the transportation of large surface contaminated objects. It paves the way for similar purpose-designed modules for the transport of large components, thereby maximising the efficient use of resources.

REFERENCES

IAEA Safety Series No.6 - Regulations for the Safe Transport of Radioactive Material, 1985 Edition (As Amended 1990).

ISO 1496-1: 1990.
Specification and testing of Series 1 Freight Containers
Part 1: General Cargo Containers

Nuclear Electric - Health and Safety Department
Certificate of Regulatory Compliance of Package Design No.2042
Certificate No: NE/PC/IP-2/7 (85).

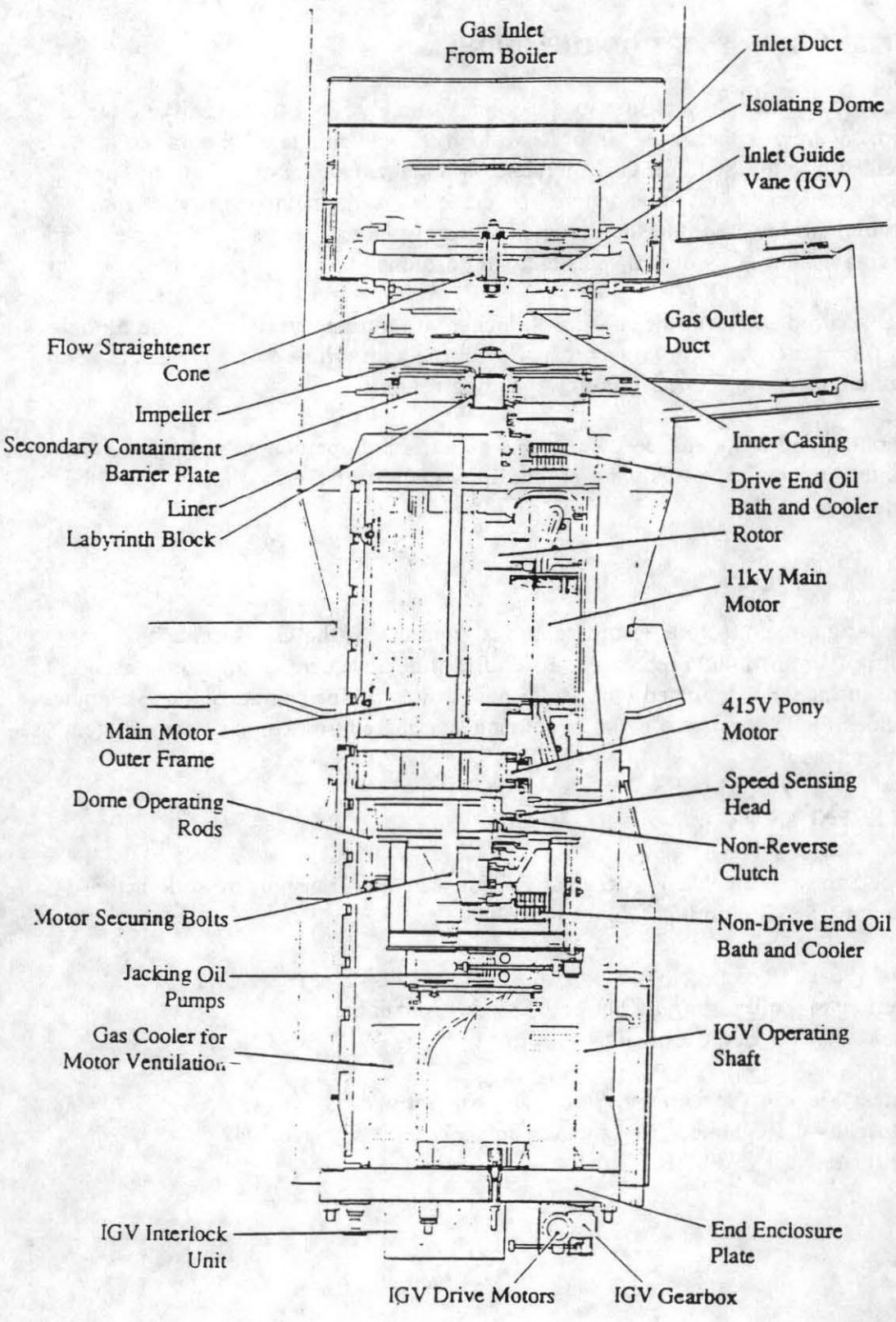

Figure 1
Schematic Layout of the Gas Circulator
Hartlepool and Heysham I

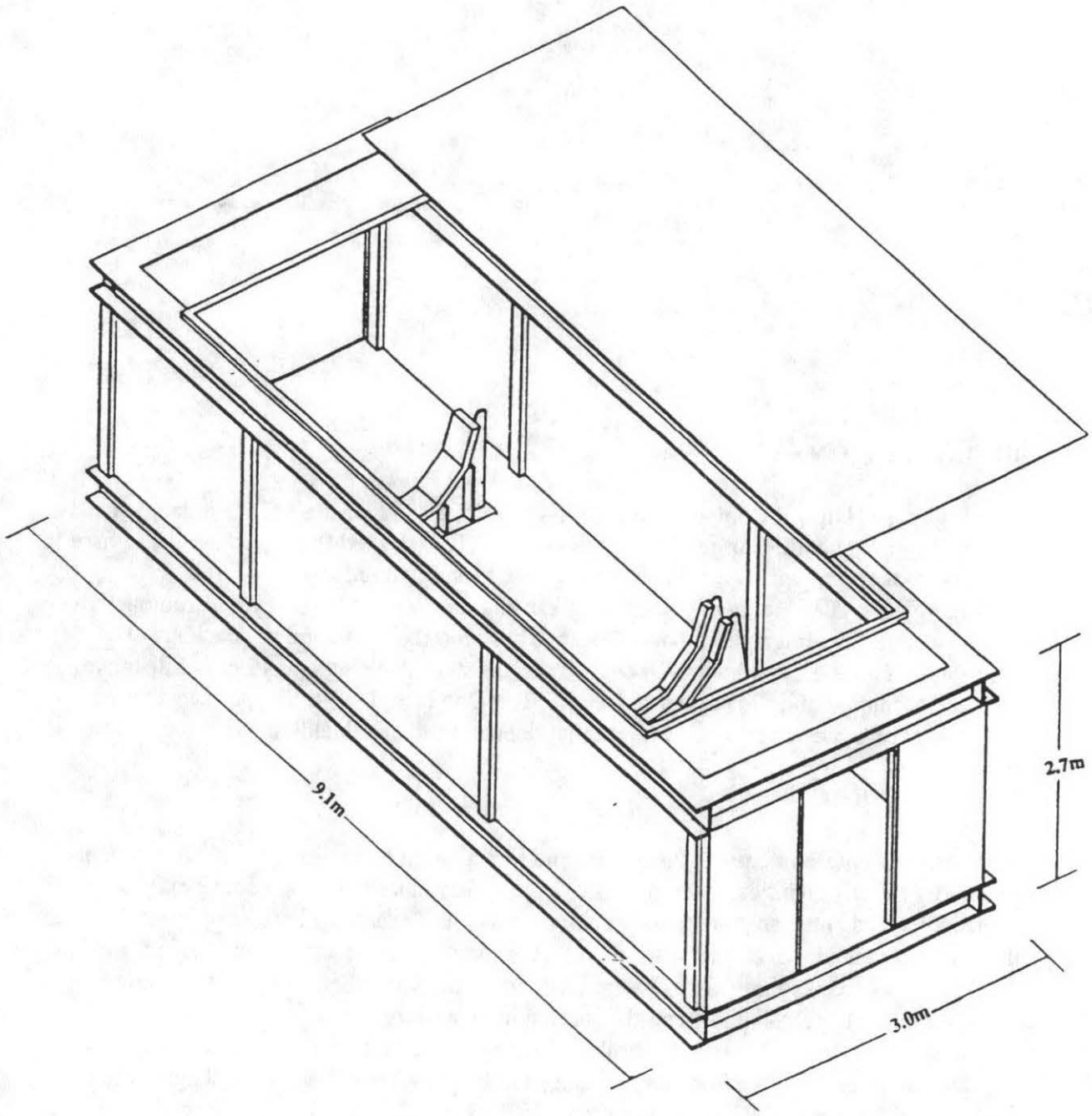

Figure 2
Schematic Layout of the Gas Circulator Transportation Module
Design No.2042 (LR 8055)